

CLAIMS

The claims are amended as follows:

1. (Currently Amended) A method of estimating end-to-end path capacity in a network, comprising:
 - probing an end-to-end path to identify addresses of all hops on the end-to-end path;
 - generating a pair of time-stamp request packets;
 - transmitting the pair of time-stamp request packets to at least one hop two consecutive hops on the end-to-end path;
 - generating a first time-stamp at a first hop of the two consecutive hops and a second time-stamp at a second hop of the two consecutive hops, in response to the pair of time-stamp request packets with the hop; and
 - processing the first time-stamp and the second time-stamp to produce at least one QoS estimate of a link that couples the two consecutive hops on the end-to-end path.
2. (Original) The method of claim 1, wherein probing on the end-to-end path comprises using a Traceroute application to identify hops on the end-to-end path.
3. (Original) The method of claim 1, wherein probing the end-to-end path occurs from one selected from a group consisting of a source node, a destination node, and both a source node and a destination node.
4. (Original) The method of claim 1, wherein processing the time-stamp is performed at one selected from a group consisting of a source node, a destination node, and both a source and destination node.
5. (Original) The method of claim 1, wherein the time-stamp request packets are ICMP requests.
6. (Original) The method of claim 1, wherein the number of generated and processed time-stamp request packets is at least five.

7. (Original) The method of claim 1, further comprising generating pairs of time-stamp request packets more often to specific hops on the end-to-end path.

8. (Original) The method of claim 7, wherein hops subject to more frequent probing are determined based on at least one of:

a variation pattern of utilization;
a queuing delay, a queue size, a processing delay, an available bandwidth, and a congestion status.

9. (Original) The method of claim 1, further comprising generating time-stamp requests less often to specific hops on the end-to-end path.

10. (Original) The method of claim 9, wherein hops subject to less frequent probing are determined based on at least one of:

a variation pattern of utilization;
a queuing delay, a queue size, a processing delay, an available bandwidth, a congestion status.

11. (Original) The method of claim 1, further comprising introducing certain latency between consecutive time-stamp request packet transmissions.

12. (Original) The method of claim 1, further comprising increasing the time-stamp request packet size by adding dummy data to the time-stamp request packet to increase sensitivity in the case of a fast link.

13. (Original) The method of claim 5, further comprising increasing the ICMP request size by adding dummy data in an IP payload field of ICMP request to increase sensitivity in the case of a fast link.

14. (Original) The method of claim 1, wherein the QoS estimate comprises a link and path capacity.

15. (Currently Amended) The method of claim 1, wherein the QoS estimate comprises an estimate of queuing delay at the hop of the two consecutive hops.

16. (Original) The method of claim 1, wherein the QoS estimate comprises an estimate of link and path utilization.

17. (Original) The method of claim 1, wherein the QoS estimate comprises an estimate of link and path available bandwidth.

18. (Currently Amended) The method of claim 1, wherein the QoS estimate comprises an estimate of interfering flows at one of the two consecutive hops~~the hop~~.

19. (Original) The method of claim 1, further comprising restarting probing of the end-to-end path in the case of a change in routing tables.

20. (Currently Amended) An article of manufacture having one or more recordable media storing instructions thereon which, when executed by a system, cause the system to estimate end-to-end path capacity in a network by:

probing an end-to-end path to identify addresses of all hops on the end-to-end path;

generating a pair of time-stamp request packets;

transmitting the pair of time-stamp request packets to two consecutive hops~~at least one hop~~ on the end-to-end path;

generating a first time-stamp at a first hop of the two consecutive hops and a second time-stamp at a second hop of the two consecutive hops, in response to the pair of time-stamp request packets ~~with the hop~~; and

processing the first time-stamp and the second time-stamp to produce at least one QoS estimate of a link that couples the two consecutive hops on the end-to-end path.

21. (Currently Amended) A router comprising:

a queue to store outgoing packets;

IP processing coupled to the queue to probe an end-to-end path in a network to identify addresses of all hops on the end-to-end path, generate and transmit a pair of time-stamp request packets to two consecutive hops at least one hop on the end-to-end path, and receive and process a first time-stamp generated at a first hop of the two consecutive hops and a second time-stamp generated at a second hop of the two consecutive hops in response to the pair of time-stamp request packets from the at least one hop to produce at least one QoS estimate of a link that couples the two consecutive hops on the end-to-end path.

22. (Currently Amended) A method of estimating end-to-end path capacity in a network, comprising the steps of:

probing an end-to-end path to identify addresses of a plurality of hops on the end-to-end path;

generating at least one time-stamp request packet with an origination node;

sending the time-stamp request packet to at least one respective hop on the end-to-end path, the at least one time-stamp request packet with having an origination address of the origination node spoofed to that of another hop on the network;

generating at least one time-stamp with the hop; and

processing in at least one hop on the network the at least one time-stamp to produce a QoS estimate.

23. (Original) The method of claim 22, wherein probing the end-to-end path comprises using a Traceroute application to identify addresses of the plurality of hops.

24. (Original) The method of claim 22, wherein the origination address is that of a source node on the end-to-end path.

25. (Original) The method of claim 22, wherein the origination address is that of a destination node on the end-to-end path.

26. (Original) The method of claim 22, wherein probing the end-to-end path is generated from a source node.
27. (Original) The method of claim 22, wherein probing the end-to-end path is generated from a destination node.
28. (Original) The method of claim 22, wherein probing the end-to-end path is generated from a source node and a destination node.
29. (Original) The method of claim 22, wherein the QoS estimate comprises an estimate of link and path capacity.
30. (Original) The method of claim 22, wherein the QoS estimate comprises an estimate of queuing delay at the hop.
31. (Original) The method of claim 22, wherein the QoS estimate comprises an estimate of link and path utilization.
32. (Original) The method of claim 22, wherein the QoS estimate comprises an estimate of link and path available bandwidth.
33. (Original) The method of claim 22, wherein the QoS estimate comprises an estimate of interfering flows at the hop.
34. (Original) The method of claim 22, further comprising refining the QoS estimate by taking into consideration a propagation delay.
35. (Currently Amended) An article of manufacture having one or more recordable media storing instructions thereon which, when executed by a system, cause the system to estimate end-to-end path capacity in a network by:

probing an end-to-end path to identify addresses of a plurality of hops on the end-to-end path;

generating at least one time-stamp request packet with an origination node;

sending said time-stamp request packet to at least one respective hop on the end-to-end path, the at least one time-stamp request packet having with an origination address of said origination node spoofed to that of another hop on said network;

generating at least one time-stamp with said hop; and

processing in at least one hop on said network said at least one time-stamp to produce a QoS estimate.

36. (Currently Amended) A router comprising:

a queue to store outgoing packets;

IP processing coupled to the queue to receive at least one time-stamp request packet with an origination node, to at least one respective hop on the end-to-end path the at least one time-stamp request packet having with an origination address of the origination node spoofed to that of another hop on the network, to generate at least one time-stamp, and to process the at least one time-stamp to produce a QoS estimate.

37. (Currently Amended) A method of estimating end-to-end path QoS in a network, comprising:

probing an end-to-end path to identify a plurality of hops with a node;

generating a pair of time-stamp request packets with the node;

transmitting the pair of time-stamp request packets to at least one hop two consecutive hops on the end-to-end path;

generating a first time-stamp at a first hop of the two consecutive hops and a second time-stamp at a second hop of the two consecutive hops, in response to the pair of time-stamp request packets with the hop;

transmitting the first time-stamp and the second time-stamp to the node; and

processing the at least one first time-stamp and second time-stamp to produce a QoS estimate of a link that couples the two consecutive hops on the end-to-end path.

38. (Original) The method of claim 37, wherein the node may be selected from a group of nodes including a source node, a destination node or an independent node.

39. (Original) The method of claim 37, wherein the QoS estimate comprises a link and path capacity.

40. (Original) The method of claim 37, wherein the QoS estimate comprises an estimate of queuing delay at the hop.

41. (Original) The method of claim 37, wherein the QoS estimate comprises an estimate of link and path utilization.

42. (Original) The method of claim 37, wherein the QoS estimate comprises an estimate of link and path available bandwidth.

43. (Original) The method of claim 37, wherein the QoS estimate comprises an estimate of interfering flows at the hop.

44. (Currently Amended) An article of manufacture having one or more recordable media storing instructions thereon which, when executed by a system, cause the system to estimate end-to-end path capacity in a network by:

probing an end-to-end path to identify a plurality of hops with a node;

generating a pair of time-stamp request packets with the node;

transmitting the pair of time-stamp request packets to two consecutive hops on the end-to-end path at least one hop;

generating a first time-stamp at a first hop of the two consecutive hops and a second time-stamp at a second hop of the two consecutive hops, in response to the pair of time-stamp request packets with the hop;

transmitting the first time-stamp and the second time-stamp to the node; and

processing the first time-stamp and the second time-stamp to produce a QoS estimate of a link that couples the two consecutive hops on the end-to-end path.

45. – 56. (Cancelled)

57. (Currently Amended) A method comprising:
probing an end-to-end path to identify capacity of routers on the end-to-end path;
transmitting a pair of ping requests to two consecutive hops~~a-hop~~ on the path;
receiving a first ping reply from a first hop of the two consecutive hops and a second ping reply from a second hop of the two consecutive hops, in response to the pair of ping requests, the first ping reply indicating a first time-stamp generated at the first hop and the second ping reply indicating a second time-stamp generated at the second hop; and
processing the first ping reply and the second ping reply to generate a quality of service (QoS) estimate of a link that couples the two consecutive hops on the end-to-end path.

58. (Original) The method defined in Claim 57 wherein the hop comprises a hop on an IEEE 802.11 wireless local area network (LAN).

59. (Currently Amended) An article of manufacture having one or more recordable media storing instructions thereon which, when executed by a system, cause the system to:
probe an end-to-end path to identify capacity of routers on the end-to-end path;
transmit a pair of ping requests to two consecutive hops~~a-hop~~ on the path;
receive a first ping reply from a first hop of the two consecutive hops and a second ping reply from a second hop of the two consecutive hops, in response to the pair of ping requests, the first ping reply indicating a first time-stamp generated at the first hop and the second ping reply indicating a second time-stamp generated at the second hop; and
process the first ping reply and the second ping reply to generate a quality of service (QoS) estimate of a link that couples the two consecutive hops on the end-to-end path.

60. – 61. (Cancelled)

62. (Currently Amended) A method of estimating a QoS value for an end-to-end path in a network, comprising the steps of:

generating a pair of ping request packets with a first hop on the end-to-end path;
transmitting the pair of ping request packets to a second hop ~~two consecutive hops~~ on the
end-to-end path;
receiving, at the first hop, a ~~first ping reply from the second hop indicating a first time-~~
~~stamp from a first one of the two consecutive hops and a second ping reply indicating a second~~
~~time-stamp from a second one of the two consecutive hops~~, in response to the pair of ping
request packets; and
calculating a QoS value ~~of a link that couples the two consecutive hops on the end-to-end~~
~~path as a function of the first ping reply and the second ping reply.~~